Shuttle Challenger

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Risk Creep

The Normalization of Deviance

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The RISCO MANUS CO.

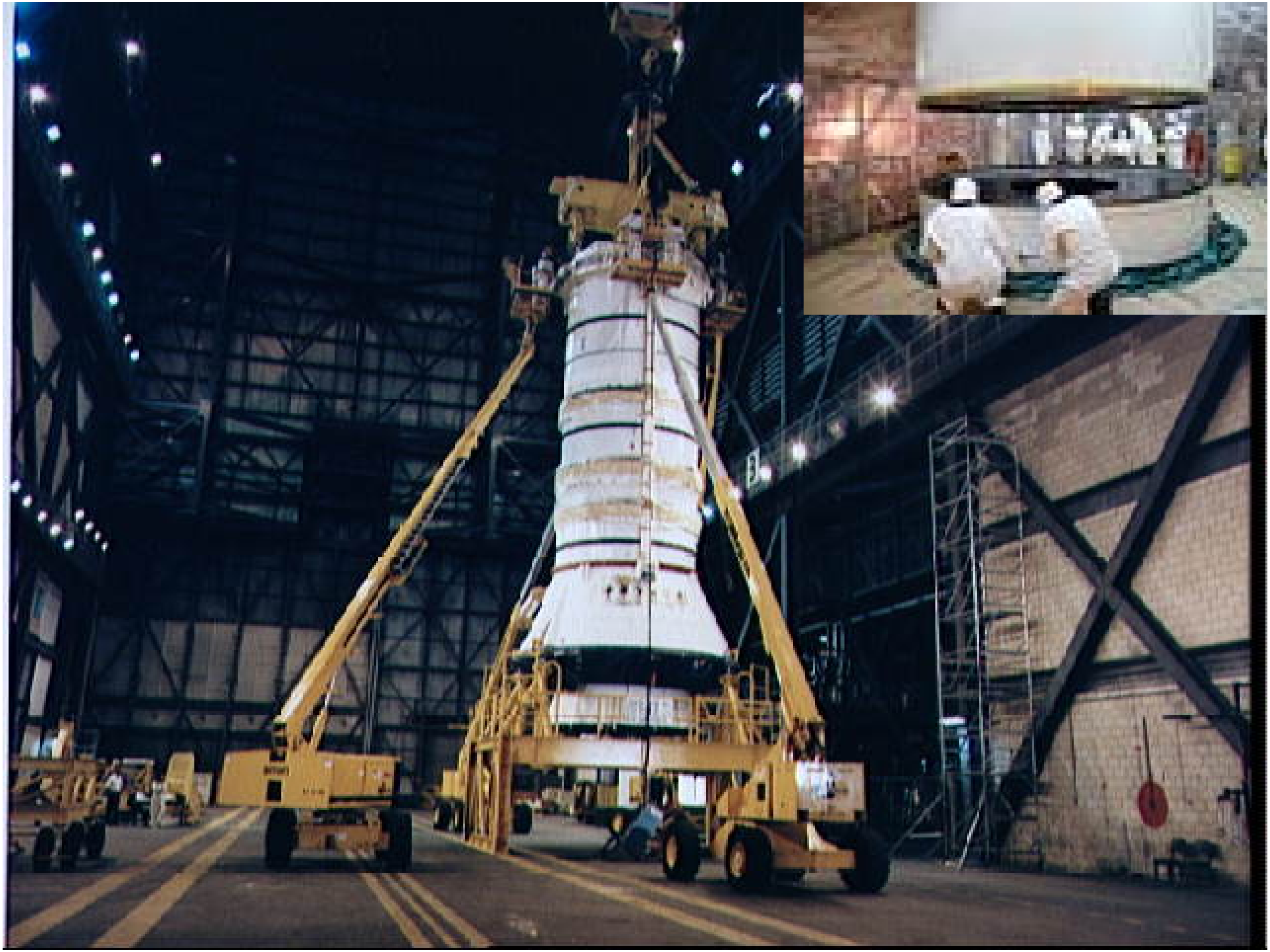
Case Study

Case Study

Challenger Risk Creep / Topics

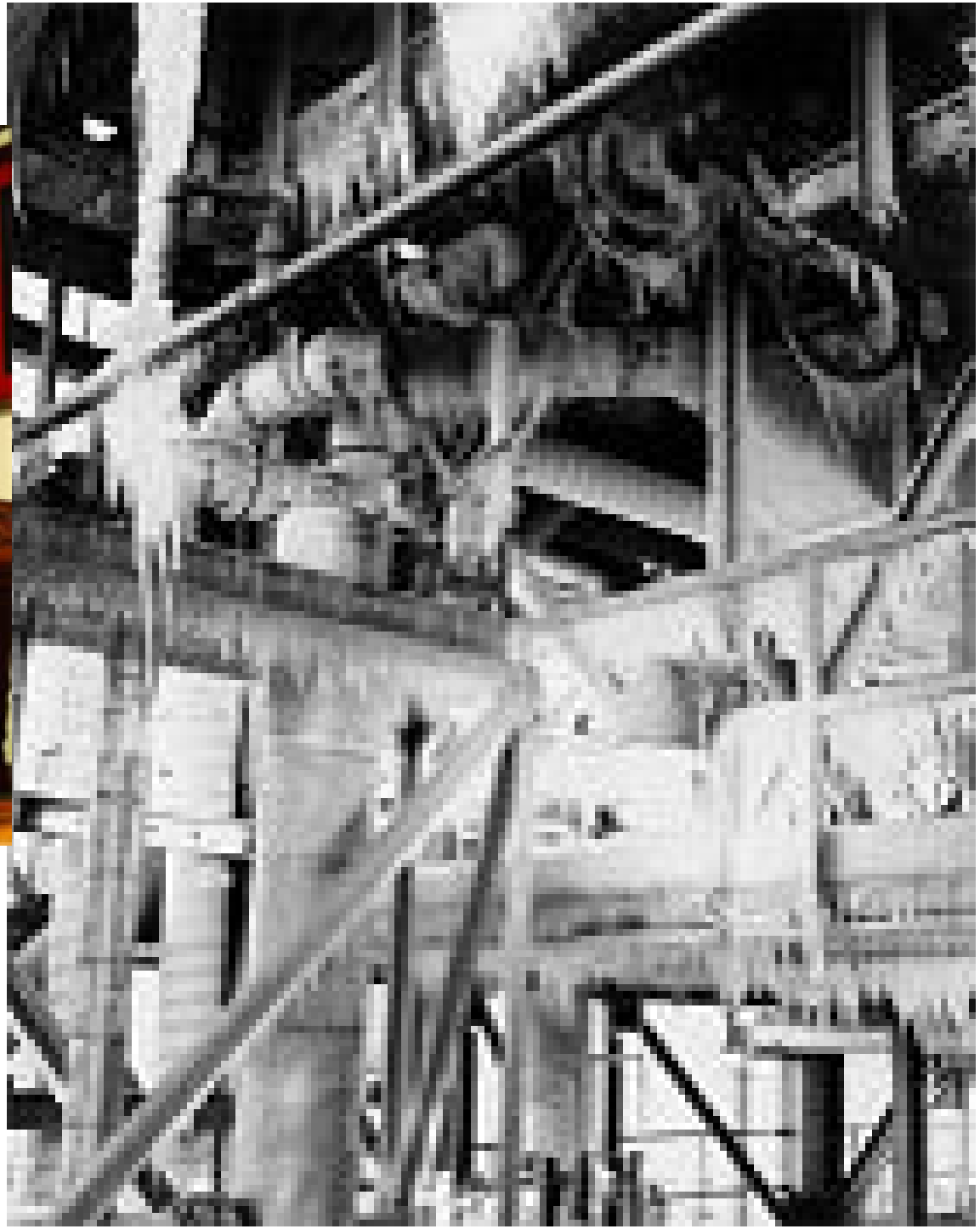
- **Reminders**
- **Decision**
- **Mission/Hardware Failures**
- **Failure RAC Assignment** **(Risk Assessment Code)**
- **Risk Control Measures**
- **Normalization of Deviance**

Diane Vaughan, The Challenger Launch Decision, **University of Chicago Press**



Roger Boisjoly

KSC pad night
before launch



Challenger Launch Photo

Challenger Launch Photo

Decision Theory

Vaughan p. 37, 62-63, 195, 247

- **Cultural beliefs . . . create unreflective, routine, taken-for-granted scripts that become part of individual worldview.**
  - **Worldview is not easily altered or dismantled because individuals tend to disavow knowledge contradicting it. – <u>We find what we expect of find.</u>**
- **Institutional arrangements constrain individual behavior penetrating organizations as categories of structure, thought & action shaping thought in some directions & not others.** **DiMaggio & Powell,** ***The New Institutionalism in Organizational Analysis*****, p.10-11**
- **Small precedents established early have larger consequences later as culture, once created, shapes subsequent decisions**
- **The 1st decision in a decision stream does not survive as precedent unless that original decision is validated by the outcome & by the outcomes of subsequent decisions.**

Decision Theory

Vaughan p. 248, 372

- **The very act of writing or reporting commits the author to a rendition of the world.**
- **Going public binds people to their actions.**
- **Disqualification Heuristic: Mind-set leading decision makers to neglect information that contradicts convention. Lee Clark, *Acceptable Risk***
- **Hierarchy becomes more salient for people in stressful situations. Karl Weick, *Vulnerable System*, p. 589**

➢ **RESULTS: Highly trained individuals, their scientific & bureaucratic procedures giving false confidence in their own objectives, can have their interpretation of information framed in subtle, powerful & often unacknowledged ways**

Decision Implementation

(Normalization of Technical Deviation) Ch. 4

- **SRB Workgroup 3-factor technical rationale** p.120
  1. **Safety Margin**
  2. **Experience Base**
  3. **Self-limiting**

➢ **Supported by belief of redundancy**

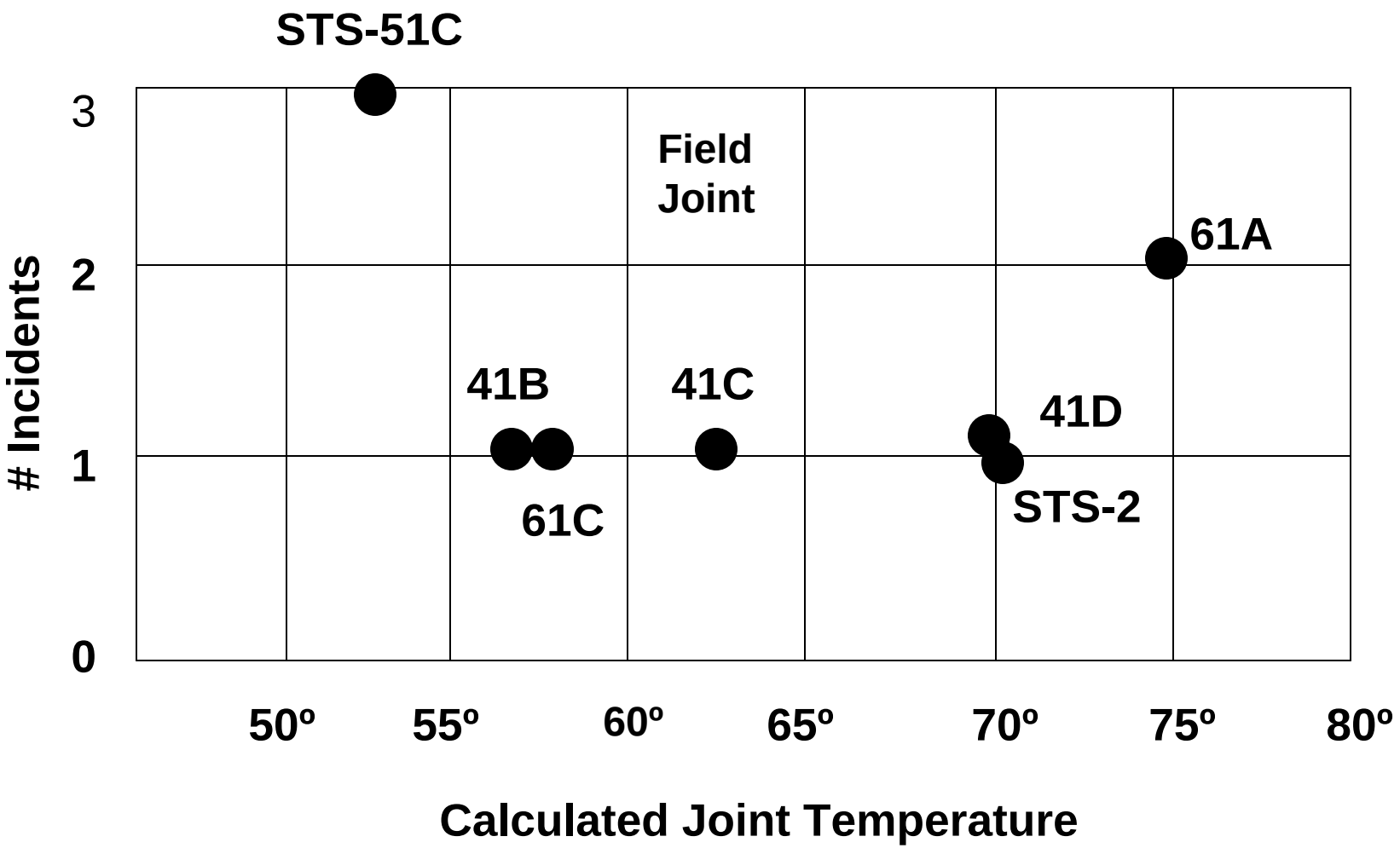
Mistakes are socially organized & systematically produced. P. 394

Shuttle Challenger Risk Creep

- **STS-2 (November 1981) - 1st evidence of impingement erosion.**
- **STS-6 (April 1983) Heat reached (but not eroded) both a right & left primary O-ring nozzle joints - the 1st time heat reached 2 joints.**
- **STS-41B (February 1984) suffered erosion of the primary O-ring in 2 joints - the 1st time erosion in 2 joints.**
- **STS 41-D (August 1984) 1st evidence of blow-by.**
- **STS-51C (January 1985) had blow-by & erosion of the primary seal on 2 field joints & for the 1st time, hot gas contact on a secondary seal.**
- **STS-51B (April 29, 1985) suffered a nozzle joint primary O-ring burned completely through.**
- **STS 51-F (July 29, 1985) post launch inspection found a hot gas path though putty but no erosion.**

- **STS 51L (January 1986) <u>Challenger</u>**

Temperature Analysis



Risk Management

The NASA risk matrix shows the application of consequence & likelihood in determining a Risk Assessment Code (RAC) & a qualitative (high, medium, low) risk rating.

	LIKELIHOOD ESTIMATE				
CONSEQUENCE CLASS	**A**	**B**	**C**	**D**	**E**
I	**1**	**1**	**2**	**3**	**4**
II	**1**	**2**	**3**	**4**	**5**
III	**2**	**3**	**4**	**5**	**6**
IV	**3**	**4**	**5**	**6**	**7**

High Risk	
Medium Risk	
Low Risk	

Risk Matrix Showing Risk Assessment Codes (RAC)

NASA NPR 8000.4 Risk Management Procedural Requirements

Risk Management

MIL-STD-882D
APPENDIX A

TABLE A-III. **Example mishap risk assessment values.**

SEVERITY PROBABILITY	Catastrophic	Critical	Marginal	Negligible
Frequent	1	3	7	13
Probable	2	5	9	16
Occasional	4	6	11	18
Remote	8	10	14	19
Improbable	12	15	17	20

"Risk (an ongoing process) is not a fixed attribute of some object, but constructed by individuals from past experience & present circumstances & conferred upon the object or situation." **Vaughan. p. 62**

Challenger Risk Creep

- **(4) STS-2 (Nov. 1981) - 1st evidence of impingement erosion.**
- **(3) STS-6 (Apr. 1983). Heat reached but not eroded both a right & left primary O-ring nozzle joints - the 1st time heat reached 2 joints.**
- **(2) STS-41B (Feb. 1984) suffered erosion of the primary O-ring in 2 joints - the 1st time erosion in 2 joints.**
- **(1) STS 41-D (Aug. 1984) 1st evidence of blow-by.**
- **( ) STS-51C (Jan. 1985) had blow-by & erosion of the primary seal on 2 field joints & for the 1st time, hot gas contact on a secondary seal.**
- **( ) STS-51B (Apr. 29, 1985) suffered a nozzle joint primary O-ring burned completely through.**
- **( ) STS 51-F (July 29, 1985) post launch inspection found a hot gas path though putty but no erosion.**

- **( ) STS 51L (Jan. 1986) <u>Challenger</u>**

Risk Control Measures

- **(4) STS-2 (November 1981)**
  - **calculated the maximum impingement erosion of .090 inches**
  - **Tested the seal with .095" erosion under 3000 psi - three times the amount the rings would see at peak ignition**
  - **Program commenced putty composition test**
- **(3) STS-6 (April 1983)**
- **(2) STS-41B (February 1984)**
  - **Problem report filed in MPAS (Marshall Problem Assessment Center)**
  - **A new leak check performed at Kennedy Space Center as "fine-tuning" added to the blowholes by weakening the putty.**
    - **Test increased from 50 psi to 100 psi then again raised to 200 psi on the field joints**
- **STS-41C (April 1984)**
  - **O-ring analysis discussed in each level of the STS-41C Flight Readiness Review**

Risk Control Measures

- (1) STS 41-D (August 1984)
- ( ) STS-51C (January 1985)
  - O-ring task force formed
  - Cold temperature 1st listed as a concern
- ( ) STS-51B (April 29, 1985)
  - Launch Constraint imposed on all following missions
  - Program had returned to the 100 psi joint pressure test then after this mission returned to the 200 psi test
  - Further analysis & test commenced
- ( ) STS 51-F (July 29, 1985)

Normalization of Deviance

- (4) STS-2 (November 1981)
- (3) STS-6 (April 1983)
- (2) STS-41B (February 1984)
  - Three factor standard self developed by this time
    - The experience base
    - The safety margin
    - The belief that erosion was self-limiting
- STS-41C (April 1984)
  - O-ring analysis discussed in each level of the STS-41C Flight Readiness Review

Normalization of Deviance

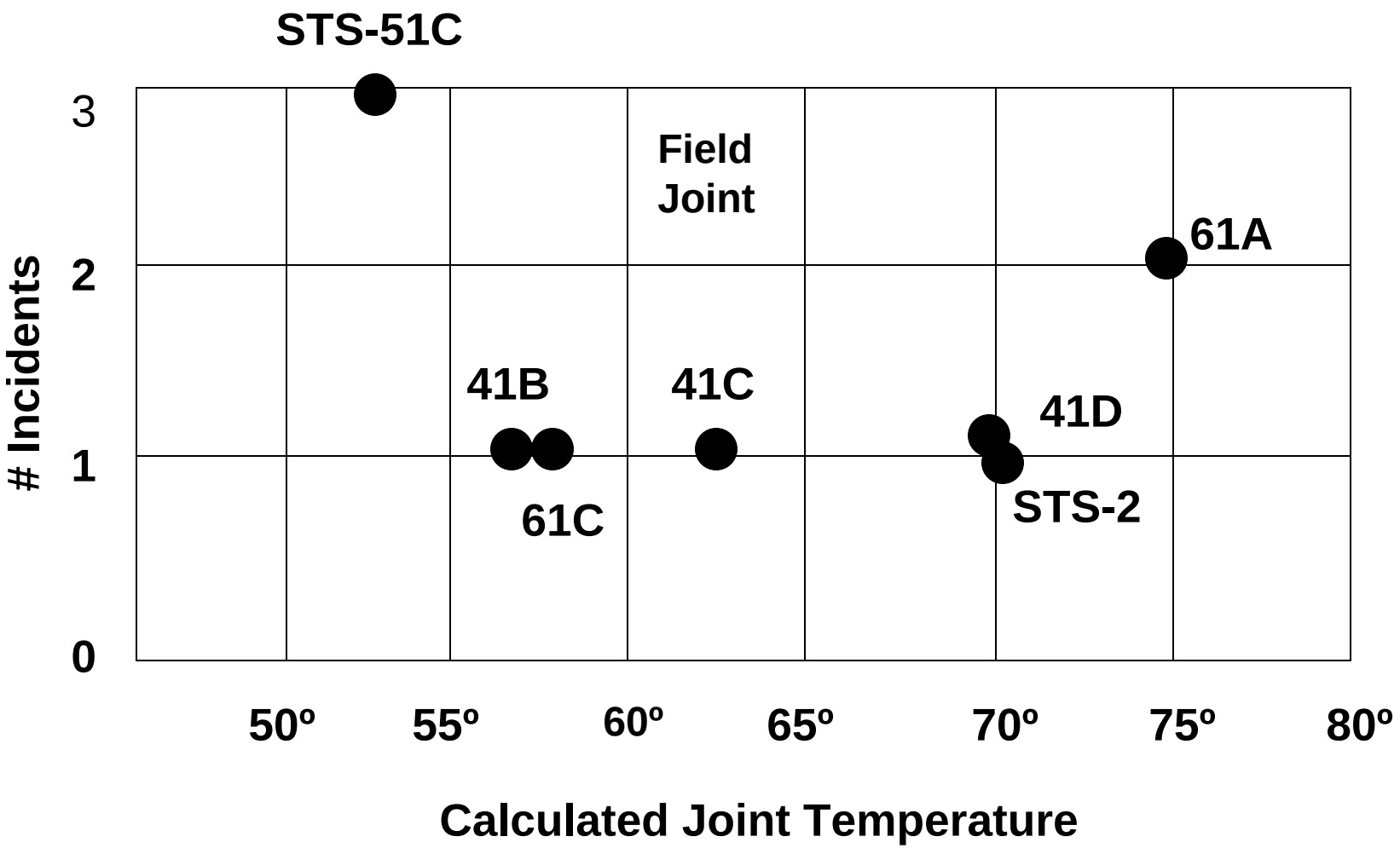
- (1) STS 41-D (August 1984)
- ( ) STS-51C (January 1985)
  - An O-ring task force formed
- ( ) STS-51B (April 29, 1985)
- ( ) STS 51-F (July 29, 1985)

"Little by little, NASA was accepting more & more risk in order to stay on schedule." "These little pieces of risk add up until managers are no longer aware of the total program risk." CAIB p139

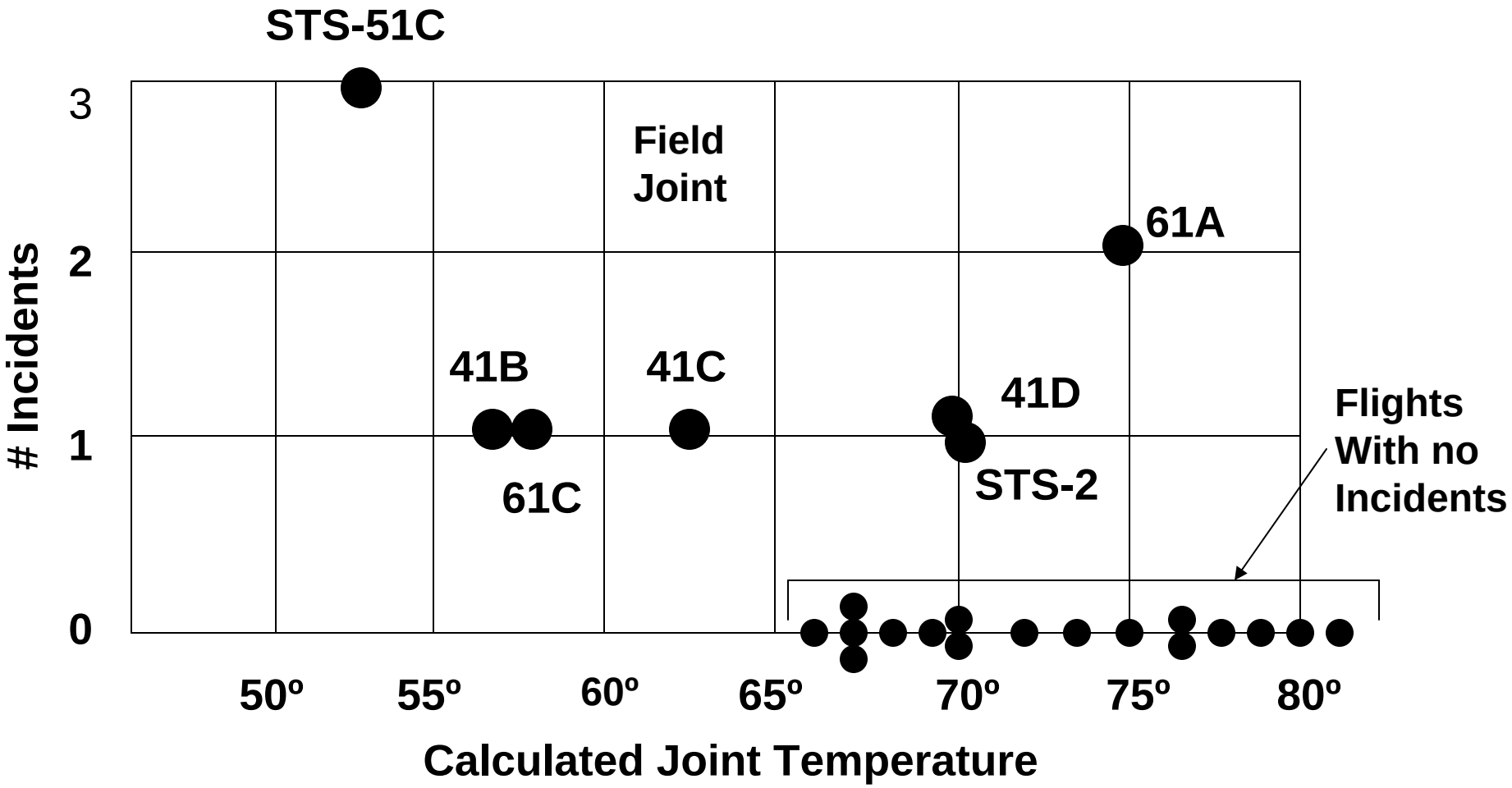
Normalization of Deviance
Summarized per CAIB

- **“Because both problems had been previously normalized, resources sufficient for testing or hardware were not dedicated. The Space Shuttle Program had not produced good data on the correlation between cold temperature & O-ring resilience or good data on the potential effect of bipod ramp foam debris hits.”** P200
- **“Because ill-structured problems are less visible & therefore invite the normalization of deviance, they may be the most risky of all.”** p203

Temperature Analysis

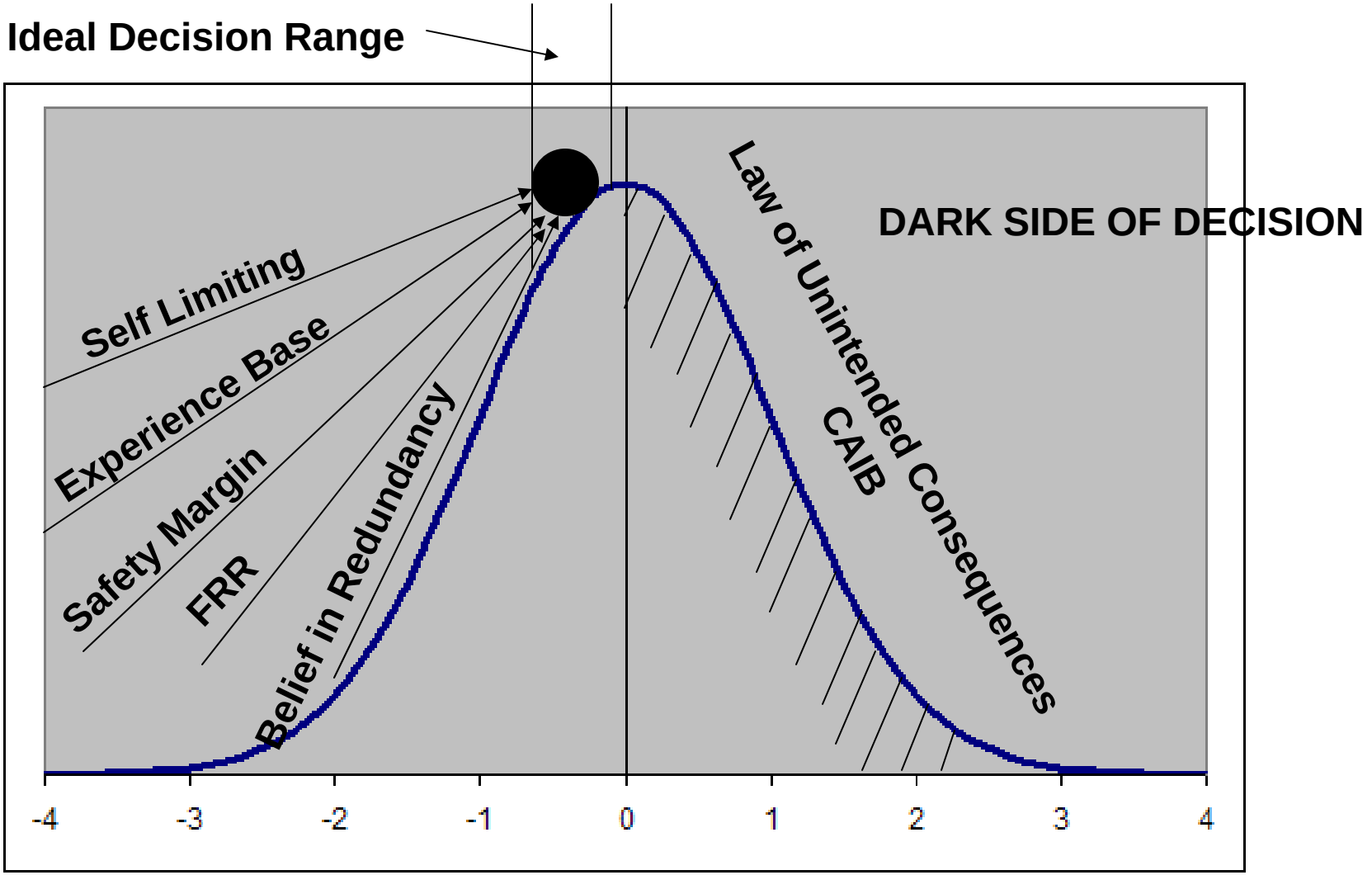


Post-Accident Temperature Analysis

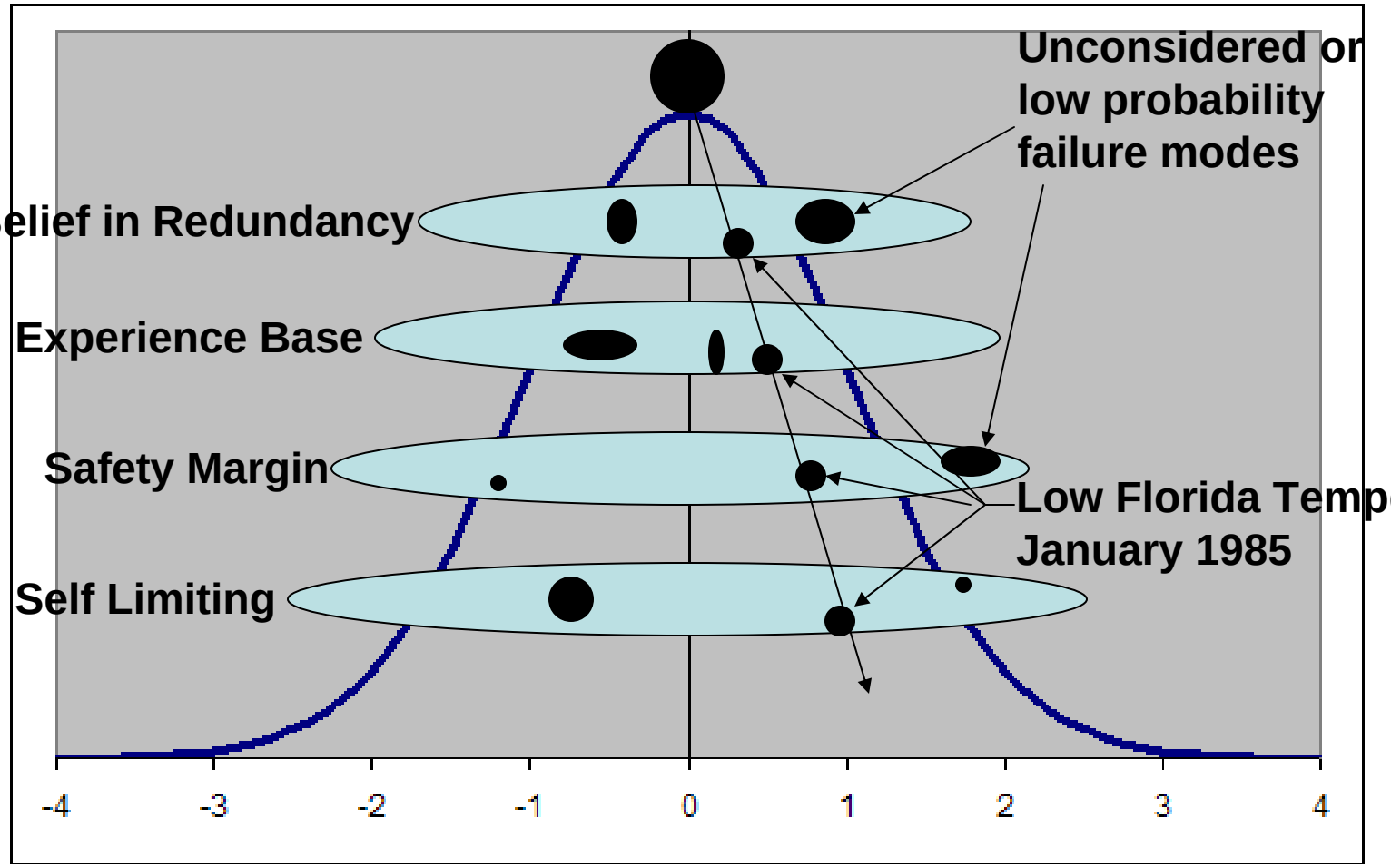


Plotted by A. Keel, Jr., (Executive Dir.) & R. Kehrli, (Dept. of Justice Attorney)

Decision Expression 1



Decision Expression 2
Swiss Cheese Variation



Questions

CONCLUSION

"Twice in NASA history, the agency embarked on a slippery slope that resulted in catastrophe. Each decision, taken by itself, seemed correct, routine, & indeed, insignificant & unremarkable. Yet in retrospect, the cumulative effect was stunning. In both pre-accident periods, events unfolded over a long time & in small increments rather than in sudden & dramatic occurrences." CAIB p.203

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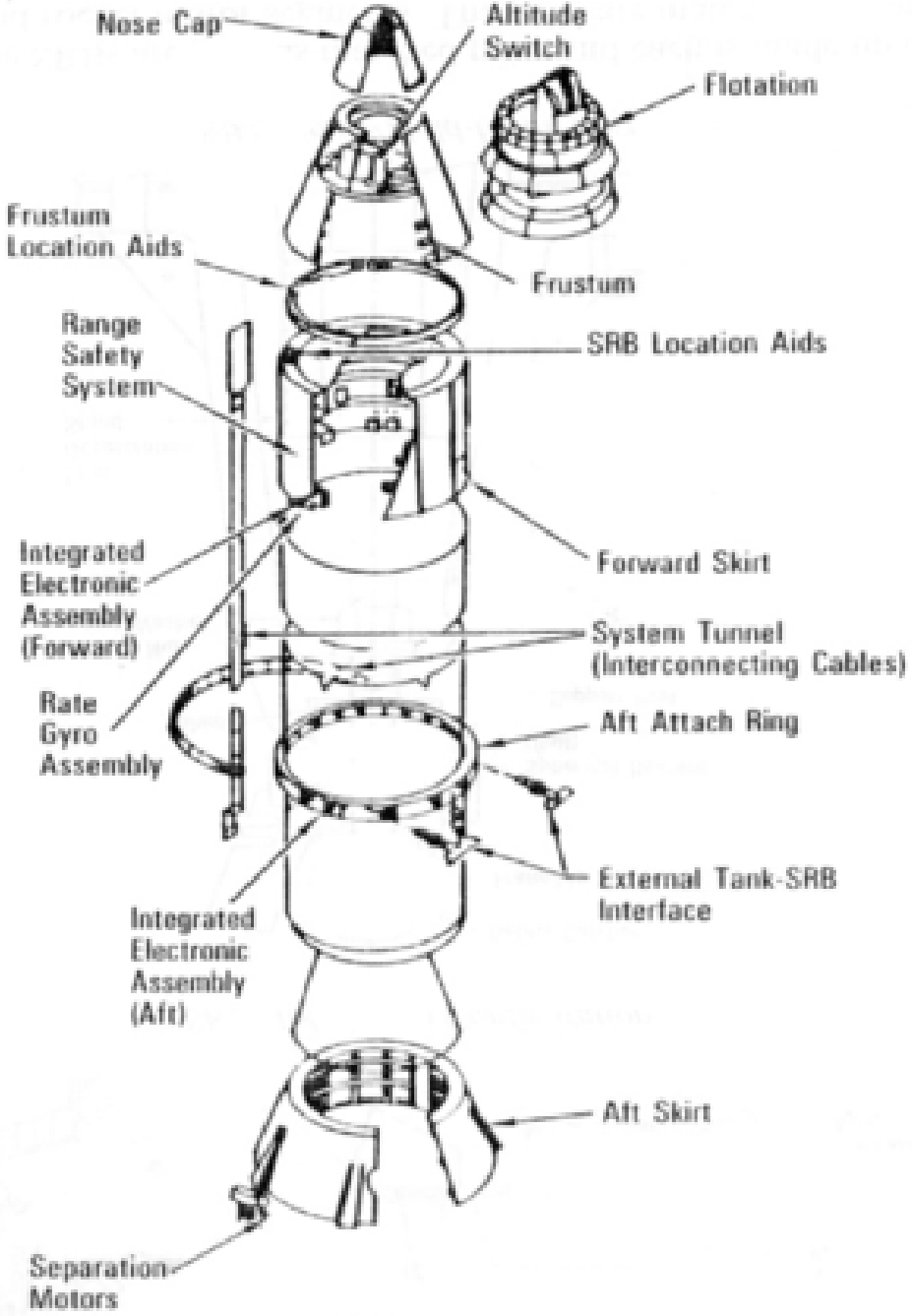
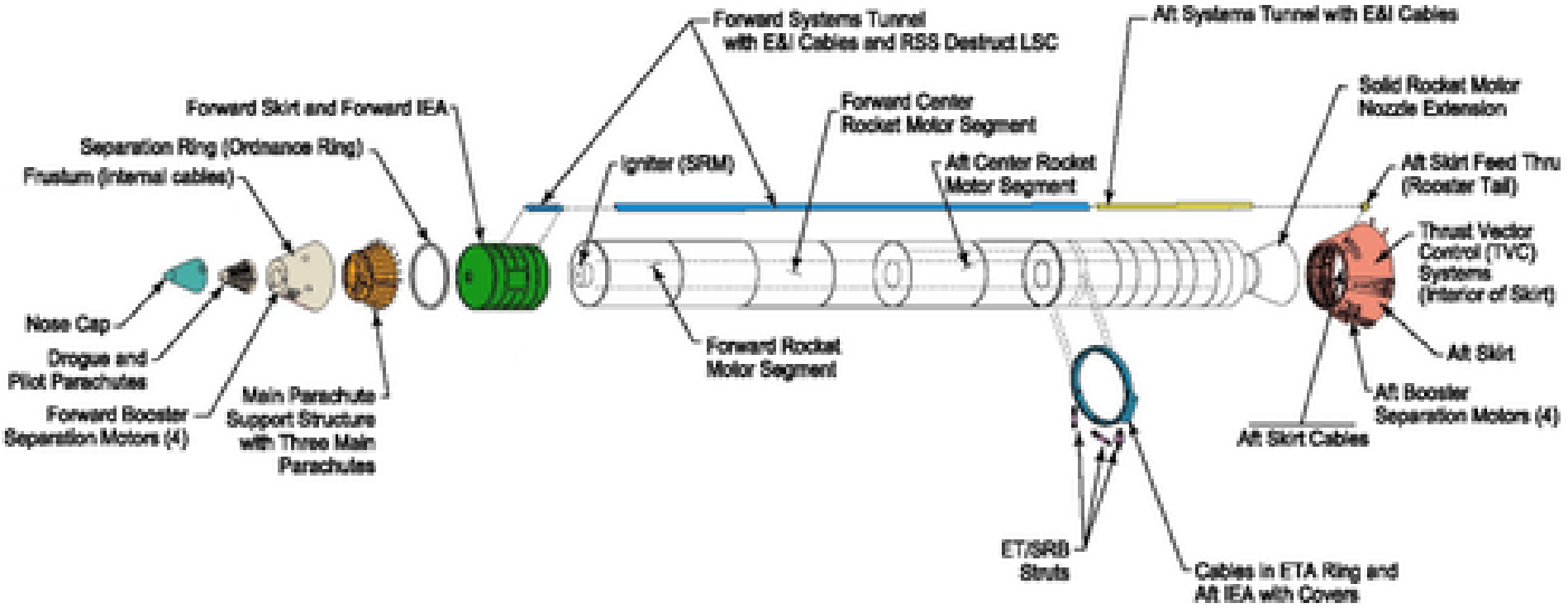
An overcautious policy often risk more than a bold one. James Monroe



Solid Rocket Booster—Exploded View


Forward Systems Tunnel
with E&I Cables and RSS Destruct LSC
Aft Systems Tunnel with E&I Cables
Solid Rocket Motor
Nozzle Extension
Forward Skirt and Forward IEA
Forward Center
Rocket Motor Segment
Separation Ring (Ordnance Ring)
Igniter (SRM)
Aft Center Rocket
Motor Segment
Aft Skirt Feed Thru
(Rooster Tail)
Frustum (internal cables)
Thrust Vector
Control (TVC)
Systems
(Interior of Skirt)
Nose Cap
Forward Rocket
Motor Segment
Drogue and
Pilot Parachutes
Aft Skirt
Forward Booster
Separation Motors (4)
Main Parachute
Support Structure
with Three Main
Parachutes
Aft Booster
Separation Motors (4)
Aft Skirt Cables
ET/SRB
Struts
Cables in ETA Ring and
Aft IEA with Covers